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It is proposed to publish from time to time, as occasion may serve, Bulletins on subjects connected with Agriculture and Horticulture in the Malay Peninsula. It is hoped that planters will send to the Director of the Botanic Gardens, Singapore, notes and observations on the cultivations of the various crops under their care. Observations on insect and fungus-pests are especially requested, and these should always be accompanied by specimens of the injurious insect or fungi either alive, or preserved in spirits, except in the case of butterflies and moths which should be sent dry in envelopes.

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Dr. Burck's Method of Treatment of the Coffee-leaf Disease in Java.

Introduction.

A number of articles have been recently published in the *Javaasche Courant* under the title of "Over de Koffieblad ziekte" by Dr. Burck, the Assistant Director of the Botanical Gardens at Buitenzorg, which are the results of some years' observations and experiments. The methods employed by Dr. Burck have been so successful in Java that it seems well worth while to publish here a condensed translation, or rather abstract, of the original papers (which are published in Dutch) in the hope that some Malayan planters may try what the results of Dr. Burck's plan may be here.

For the translation I am indebted to Mr. P. Nuy, late Secretary to the Government Savings Bank at Singapore.

The Disease.

It will be well to remind my readers of the nature of the disease and its life history which has been the subject of so much careful investigation by Professor Marshall Ward and others. The disease is well known to be due to a fungus termed *Hemileia vastatrix* which appears in the form of yellow or orange coloured spots on the upper side of the leaves, while on the under side they are covered with a fine orange powder. This powder consists of spores or seeds of the fungus, which are easily brushed off. If this is done, however, by the next day the spot is covered again with another layer of spores. This can be repeated for several days before the fungus is exhausted.

Professor Marshall Ward has estimated that each sick spot can produce 150,000 spores in a day, and can continue this production for from 7 to 11 weeks, and as there are often 60 or 70 spots upon one leaf, the number of spores produced in a coffee plantation at all affected by the disease is something enormous.

The spores are borne away by the winds and scattered far and wide. All those that fall upon a coffee leaf, and find there the requisite conditions of existence, will develop the disease in that leaf. If they fall upon the trunk of the tree, or upon the ground, or upon the leaves of other plants, or even upon the upper side of a coffee leaf they perish. When a spore falls in a drop of water on the under side of a leaf, it first increases in size by absorbing the water and after a couple of hours produces one or more tubes which enter the minute pores on the under side of the leaf known as stomata; then attacking the internal tissue of the leaf they destroy it, and the destruction of the dark green cells of the upper surface of the leaf produces the well-known yellow spot. This operation takes three or four weeks. The fungus then prepares to produce fresh spores. Some of the threads or tubes in the interior of the leaf forming bundles project through the above-mentioned pores upon the under side of the leaf and each produces on its end a small globular body, which develops into a

spore, behind this is produced another and another, till they hang down in chains, and this is continued till the fungus is exhausted.

Sometimes the spores instead of being drifted away by the wind to other leaves, fall upon the same leaf, and attack it again; this produces the secondary spots, but, as a rule, the leaf is exhausted by the time that the spores are produced, and after turning brown drops off.

As long as there are but few spots on the leaf, and the attack is but slight, little harm is done. It is not only the destruction of so much leaf tissue by the fungus which injures the plant, but it appears probable also that the tubes of the fungus suck out the nourishment from the leaf, and as soon as the leaf has no longer a sufficient supply for itself, it perishes.

Conditions for the germinating of the Spores.

Dr. Burck in his examination of the germination of the spores, noticed that spores taken from the same sick spot and deposited in a drop of water, at different periods of the day, did not always germinate. By following up this clue he found that, besides air and water, darkness also was a requisite of successful germination. If spores are put in a drop of oxygenated water and exposed to light they do not germinate. Pure sunlight is not essential to prevent their growth. The diffused light of the laboratory at some distance from the window prevented any development. If, however, the spores are taken into the dark, in 2 hours or 2½ hours they germinate and emit the tube. Total darkness, however, is not necessary for this. Further investigation showed that the light absolutely killed the spores, after a short exposure to it, even if removed into the dark, they no longer are able to produce the tube. Of spores placed at a distance of six or seven feet from the window for 1¼ hours most were dead, and after an exposure of an hour and three-quarters all were dead. This, however, it must be remarked, applies to spores in water only. If kept quite dry they will withstand the sunlight for a long time. Coffee leaves with the spores still suspended from the sick spots may be exposed to the influence of sunlight till they are quite dried up without losing life. It is, therefore, the spore swelling with the water which it has absorbed that is killed by the light. Further, it was noticed that the blue rays of the spectrum were the fatal ones. In the red rays the spores grew as rapidly as in complete darkness. Even the strongest petroleum light had no effect upon the spore, the actinic rays being too weak to kill it.

The requisite for germination are thus, water, air and more or less complete darkness. For the further stages it is requisite that it fall upon the under side of a coffee leaf, for on the upperside are none of the stomata by which alone it can penetrate to the inner tissue of the leaf. These observations are not without practical interest, for the injurious effect of sunlight upon the spores explains to us the fact well-known to planters that the leaves of the upper branches of untopped trees are seldom attacked so badly as to affect the ripening of the fruit. Repeatedly, Dr. Burck

affirms he learnt from the planters in Java that generally it was the crop of the upper branches that was obtained and that of the lower branches and middle ones that there was reason to fear for.

Everyone who has seen a plantation in an advanced state of destruction will remember the bare trunk and dead side branches crowned at the top with a few tufts of leaves which have escaped the general destruction.

It is, therefore, better on the whole not to top the trees, and in the plantations where the trees have already been topped for some years, it is better to let them shoot up again. The lower sides of the upper leaves receive light of higher intensity than the middle and lower branches, and this increase of light is sufficient to kill the spores if damp. Of course, even those leaves of which the under side is fully exposed to sunlight are not free from the possibility of infection by night, but by this exposure their chances of infection are much lessened.

It might be imagined from this that the destruction of the shade trees would be desirable, but this would not avail much against the disease, as it is on the under side of the leaf that the spore can make its attack and that is shaded by the leaf itself and by the other leaves on the bush.

Fallen Leaves.

Most of those who have written about the disease have cautioned planters against allowing the fallen leaves to remain on the ground, fearing that they may affect the healthy leaves. Dr. Burck found, however, that spores taken from fallen leaves did not germinate, the reason being that they were killed by exposure to light as soon as they were wetted by rain or dew. It is indeed quite safe to leave the dead leaves upon the ground whether the upper or lower side be exposed to light. For if a leaf lies upon its upper surface the spores are killed by exposure to light; if on the lower surface they begin to grow and are then killed by the excessive wet of the rain on the ground. Should the weather be very hot and dry it will be advisable to destroy the leaves. The disease, however, rarely occurs during the dry season. Dr. Burck has, he states, only seen such a case three times and then in a plantation of one or two years' growth.

Infection of the Leaves.

The spores will not germinate in air however damp it be. They require fluid water; so that the leaf can only be affected when it is covered with drops of dew or rain.

Professor Marshall Ward thought that fresh spores put into a drop of water only began to germinate after from 12 to 24 hours, and did not enter the leaf for 48 hours after they were put into the water. If this were so, the disease could hardly exist, for where are the trees that are covered with drops of water for forty-eight hours? Besides, it must be remembered, that during heavy rain no tubes can be formed by the spores, as they would be

washed off by the constantly falling drops. The period required, is, however, very much shorter. In a number of trials, the spores germinated after 2 hours and 20 minutes, and a few hours afterwards there were tubes long enough to enter the stomata. Sometimes the operation took a longer time, but whenever the spores were alive the tube was in full growth after five or six hours.

On examining a coffee bush in the morning after a rainy night, it will be seen that the old leaves are nearly all quite dry, but the freshly unfolded leaves, soft and pale green, still retain on both sides some drops. This is due to their possessing still some of the sticky bud resin which has prevented the fall of the drops.

From this it appears that the young leaves alone can be attacked by the disease, and this is absolutely correct. On each branch the yellow spots first appear on the third pair of leaves, counting the bud as the first pair, for the second pair though probably affected does not show the spot for a month, by which time the next pair of leaves has been unfolded and a new bud is formed. This then is the appearance of a branch. The bud is not affected, the next pair is affected but not visibly, the third pair shows yellow spots, the fourth and lower pairs are more affected not only by the primary but also by the secondary spots.

Much importance attaches to this observation, for it reduces the treatment of the whole plant for the disease to the treatment of a single pair of leaves upon each branch. If the primitive spots are destroyed on the third pair of leaves, the leaf is safe from further infection. The danger from secondary attacks, the real cause of the fall of the leaf, is thereby removed, and the chance of a renewed attack on the treated leaf is but small as the leaves soon pass out of the stage in which, owing to the persistence of the bud resin, the rain drops do not run off.

The rainy months of 1887 and 1888 confirmed this; the appearance was as described above with but few exceptions, but in 1889, these exceptions had become the rule. The attack was remarkably heavy, more so than any one in Buitenzorg had ever known before. As a rule, not more than three or four spots occur upon the third pair of leaves, and very often only one or two, for rain drops only remain upon these leaves irregularly and do not cover them. But now nearly all the leaves were covered with sick spots. The opening of the leaf buds which may happen in the West monsoon in Java in twenty-seven days only commenced after long intervals and consequently the latest opened pair on each branch and even the bud leaves shewed the well-known signs. What was the cause of this exceptional attack? No one in Buitenzorg remembered a West monsoon with so little rain, or with such heavy dews, and the attack is closely connected with the latter. When the dew falls upon a coffee leaf, it does not, like rain, collect in large drops and then fall off, it is deposited in drops so fine that they do not run together. In the morning after a clear night in the rainy season, it is not rare to find a coffee bush covered with dew. If there are spores on the lower side of the leaf either before or during the fall of the dew it is possible for the leaves to be very extensively and completely infected.

Predisposition to Disease.

Many planters cannot get rid of the idea that the disease can do no harm on virgin soil or on ground that has been well worked and manured. This is, however, quite erroneous. A badly nourished plant possesses, it is true, little power of resistance when attacked, but the hypothesis that a well nourished individual under favourable conditions is less or not at all liable to attack is certainly untenable. Experiment has shown that predisposition to disease or incapacity for receiving it alike do not exist. Liability to sickness is quite independent of the soil, altitude or condition of life of the plant. Dr. Burck found the disease at 5,000 feet elevation on the Tengger and other mountains as on the sea coast near Poeyer and at all intermediate levels. It was as destructive in the well manured and carefully cultivated gardens of private planters, as in the abandoned plantations of the poorer cultivators, in virgin soil and in ground long under cultivation. All sorts and varieties cultivated in the East Indies, or introduced from Brazil, and all the species in cultivation, Coffea Arabica, Liberica, Benghalensis and Maragogipe Coffee, are equally liable to the attacks, nor has a single plant been found that absolutely resists disease. Bushes which planters have affirmed to be disease proof have always take the disease when inoculated and become sick in the usual period.

Some planters imagine that the coffee plant may, during lapse of time, have become liable to the attacks from cultivation, and various are the causes to which this is ascribed. Some attribute it to the continuance of long and enforced cultivation; others to the exhaustion of the surface soil, or to the dampness of the climate. It is quite possible that long cultivation may have had some injurious effect upon the plant. But little attention has been paid to selection of seed, methods of planting, &c., but whether and in what way these have affected the plant it is difficult to decide. Correct descriptions of the Arabian coffee plant of two centuries ago we do not possess, and cannot compare it with that of the present day so as to know whether it then produced more fruit than now. However, if the soil be suitable and the plants properly and carefully cultivated we have no need to complain of the results. Dr. Peilen tells us that the Arabian coffee in its native home, in Galla country in Abyssinia and at Kaffa, can produce 20 to 25 pounds in its second year. This is indeed hardly credible; but it is easily conceived that the originally introduced plants might have produced a very much larger crop than most of the trees do now. That the soil in Java has deteriorated through coffee cultivation is true, but that this predisposes the trees to the disease is negatived by the fact that the disease appears as acutely in plants grown in virgin forest ground, well cared for plantations and in pots with carefully prepared soil, as in old ground.

The suggestion of Dr. Peilen that the relative dampness of the climate has made the plant more subject to hemileia is also highly improbable, because it leads to the belief that the coffee which during two centuries of cultivation has only just begun

to feel the effects of the dampness of the climate. The disease was first noticed in Java about 1876. Can the climate have become damper during that and the following years? There is no record of meteorological observation in Java till 1879, so that the rainfall of the years preceding the appearance of the disease cannot be determined, but, if anything, it should be greater then than now because of the recent great destruction of forests to make way for cultivations. Here is a table of coffee production in three districts which have recently suffered heavily from the disease, arranged in periods of five years:—

Average yearly production.	*Samarang.*	*Cheribon.*	*Madiven.*
In 1864–1868, ...	52,700 pikuls	24,900 pikuls	60,300 pikuls
„ 1869–1873, ...	51,550 „	22,500 „	61,700 „
„ 1874–1878, ...	49,200 „	22,700 „	58,600 „
„ 1879–1883, ...	50,500 „	24,600 „	66,400 „
„ 1884–1888, ...	27,300 „	11,760 „	33,275 „

The fall in the last five years can hardly be attributed to a sudden alteration in the climate. Again, if as Dr. Peilen thinks excess of damp is the cause, mountainous districts and those parts of Java where the rainfall is heaviest, such as Buitenzorg, the disease ought to be worst. This is not the case. The theory of the same writer that the growth of the mycelium of the hemileia is dependent on the degree of concentration of the cellular fluid in the leaf from which the fungus draws its nourishment and that only when the concentration is small can the fungus grow, is not yet proved by experiment.

Eradication of the Disease.

Two plans have been invented by Dr. Burck, both of which have been attended with highly satisfactory results; one of these is a repressive, the other the preventive method of dealing with the disease.

The first of these consists of the destruction of the sick spot in the leaf. There are two forms of apparatus in use. One of these consists of a small bottle of concentrated sulphuric acid through the cork of which a glass tube passes. The coolie is supplied also with a fine needle of bamboo. The tube passes about half way down the bottle, which is filled for $\frac{1}{4}$ or $\frac{1}{3}$ its length with sulphuric acid; by this arrangement there is no fear of the sulphuric acid escaping if the bottle is upset. The operator dips the needle into the acid through the glass tube and then punctures the spot with it, a very small quantity is sufficient to destroy the fungus, and the sick spot drops out of the leaf leaving a hole, where the mycelium has been at work. This little instrument has proved most successful, but it has the disadvantage that the quantity of acid cannot be regulated and it is also liable to get upon and burn the hands of the operator. The instrument-maker, Heckking, at Sourabaya, invented a pair of scissors for cutting out the spots,

which is now used in many plantations in preference to the acid bottle. The coolies apparently work faster with the scissors and more easily. A little tube on the scissors receives the cut-out bits, and when filled these can be thrown into water or otherwise destroyed in order to prevent infection spreading, but in wet weather it does no harm to throw them down merely upon the ground.

As explained above, it is the third pair of leaves which shews the attack first; the fourth, fifth and earlier pairs are already so badly attacked, that they are not worth attempting to save. The operator then cuts out or burns with the acid the spots on the third pair on each branch. It is very rarely attacked a second time as it very soon passes out of the stage in which it is most liable to attack. In a month the third pair has become the fourth, and the pair above is the third; this pair is then treated in the same manner, and so on. Thus, two leaves on each branch, once a month, is all that is required to be treated. Leaves thus treated instead of falling in eight weeks after infection remain healthy and of a good colour for months, and the operation is so simple that it can be performed by children at a very low rate of pay.

Two cultivators, viz., Mr. F. W. Morren, President of the Blithan Company of Coffee Planters and Manager of the Estate Bantarum near Mingi, and Mr. J. A. A. Taunay, Administrator of Kawi-Sari near the same spot, have tried the plan on a very extensive scale, *i. e.*, of 220,000 and 170,000 trees respectively, and were very satisfied with the result, and other reports were equally favourable. Mr. Morren, in answer to a circular sent round for information, said that "It is my decided conviction that "not only with me but on every private plantation the method "can be applied even when the disease becomes more severe," and Mr. Taunay supported the same opinion. Several other gardens gave good reports, but in Paseroean and Bantam the reports of the treatment were unfavourable, that is to say, it seemed to have no effect on the crops. However, it must be admitted that in some cases the disease may become so bad that this treatment is useless.

The Preventive Method.

This will indisputably become the most general. It depends upon the treatment of the leaves with a chemical re-agent which acts fatally upon the fungus, but does not hurt the leaf. The spores of hemileia are very sensitive to many kinds of re-agents, organic and inorganic, and experiments were made with chloride of iron, sulphate of copper, nicotine, boric acid, sulphate of quinine, extract of cinchona bark, cupric hydroxide, mixture of lime and sulphur, cupric sulpho-steatite.

The last mentioned gave no satisfactory result, it soon washed off the leaves. Iron chloride gave good results at first, but the application on a large scale was found to be unsatisfactory on account of its hygroscopicity, which prevents an accurate proportion being taken, and its liability to decomposition, by which it soon loses its effect and is likely to injure the leaves. It is fatal

to the fungus in doses of 1 part in 7,000 parts of water. Copper sulphate is more successful. It does not decompose; it is very cheap and easily obtained. It can be obtained in the form of powder, and dissolved easily in water. One part per thousand of water was used with favourable results, but it will still kill the disease when one part is mixed with 150,000 parts of water, so that the stronger solution dose would be quite strong enough even if diluted by rain or dew to a large extent.

Sulphate of quinine is fatal at a strength of one in 2,000, and borax and boric acid at the same dilution.

One objection to copper sulphate is that the solution becomes condensed by evaporation and crystals deposited on the leaf, which burn it and make it look unsightly, especially when used for a long time consecutively. This, however, may be obviated by the addition of a little sugar which prevents crystallization, at least to a large extent.

Tobacco water, however, does not damage the leaves at all. It is more expensive than copper sulphate, but, of course, refuse tobacco can be used for the purpose and is cheap enough in Java. The liquid is applied by a spray diffuser to the under-surface of the leaves, any fungus already there is, of course, killed at once and as the liquid becomes condensed by evaporation a thin layer of tobacco extract is left on the leaf. The next rain or dew re-dissolves the extract and this prevents the spores which fall upon the leaf from germinating, gradually, of course, the rain washes away part of the tobacco and it is, therefore, necessary to treat the plant again. Tobacco water does not remain as long on the leaf as copper sulphate or iron chloride.

Treatment of young Plants.

Young plants as is well known are very liable to disease, and they often let fall a great part of their leaves before they have been transplanted to the open ground from the nursery.

This is partly due to the crowding of the little plants together and also to the necessity of sprinkling them with water during the dry season, and the slow evaporation of the water from the plants under cover. The sprinkling should be done twice a week. Plants treated like this were found to be free from disease, except where by some accident the tobacco water did not touch the leaf, although they might be surrounded by untreated plants which were extensively affected. Indeed the chance of infection then is so great that a leaf only partially wetted was sure to get ill.

It cannot be too much urged to commence sprinkling before the disease appears. If you wait till the yellow spots appear you lose many leaves without necessity. It must be remembered that when the disease is once visible on the lower leaves it is certain that one or two pairs of higher leaves are attacked and will shew the spots in a few days. You cannot save these leaves, you can only prevent the disease going further. It is thus possible to plant out all the young shrubs into the plantation free of disease

and without the loss of a single leaf. After the plants are removed to the plantation, they must still be protected by means of the scissors or sulphuric acid bottle, and also the tobacco water. A coolie is instructed to examine each plant twice a month and to destroy with acid or scissors each sick spot, and, of course, one man can look after a very large number of plants, especially if the work is commenced immediately the plants leave the nursery. Usually the disease commences on each plant sporadically, gradually spreading afterwards, so that if each primitive spot is at once removed, not only do you prevent any secondary attack, but also keep the disease sporadic and prevent a strong attack. The cost of sprinkling each plant with tobacco water twice a week, was at Buitenzorg $\frac{1}{2}$ cent (guilder) per year for labour and about $\frac{1}{10}$ cent for refuse tobacco. Dr. Burck used one "lempeng" of tobacco in a kerosine tin of 18 litres. The tobacco was put in the evening before use in warm water. Two kerosine tins were enough for 1,000 plants. As the plants get older, of course, the expenses are greater but the cost of treatment of a plant from the time of sowing in the nursery till it begins to fruit will rarely be more than $1\frac{1}{2}$ guilder cents.

The Use of Hedges against the Disease.

An examination of a thirteen-year old coffee garden at Buitenzorg shewed that the North-west side was badly attacked by disease, but it decreased on the North-east, East and South sides of the plantation in proportion to the distance from the North-west side, and again the bushes in the interior of the plantation were less badly attacked than those of the outside. Now the prevailing wind here is from the North-west, and it seems evident from this that the more a plantation is exposed to the prevailing wind the more it is liable to be affected. Further examinations shewed that the interior of the plantation is less attacked that the exterior. From this it is clear that the planting of a close hedge of coffee trees which by means of tobacco water is protected against disease and loss of leaves, is of the greatest importance in protecting the plants enclosed by the hedge from disease or at least will keep it in a sporadic state; of course more than one hedge will have to be planted where the ground is broken. The number and position of the hedges will depend on the circumstances of each plantation, and each Manager will have to judge of this for himself, remembering that the great object is to prevent one patch or plantation being affected by wind dispersal of spores from another. The hedges should be as close and thick as possible, but even if not quite close the disease in the rows of trees enclosed will not ever be so bad as not to be easily preventable by the repressive method if necessary. By this means should the hedges be as successful as there is every reason to believe they will prove to be the much dreaded disease may be simply and inexpensively combatted.

Spray Diffusers.

Two of these have been invented in Java for throwing the tobacco water or copper sulphate over the plants in the form of a

fine spray. Of these one made by the French firm BROQUET for for the mildew disease of the vines in France was found to work very well except for the great quantity used on each tree, *i.e.*, 1 litre. The chief objection to this was that it entailed the carrying about of such large quantities of the liquid and this was very cumbersome. For small patches and in cases where it is only requisite to sprinkle the dividing hedges, this instrument does very well. The Chief Engineer of the Public Works Department, T. VAN SCHAIK, and H. G. DERX, Chief Inspector of Railways, invented a machine which was superior in possessing a stronger pump and using less liquid: with this instrument a coolie could work for the whole day with two petroleum tins of liquid, about 36 litres.

In place of the hedge of coffee bushes constantly sprinkled with tobacco water, fences of other bushes may be used and of these none are more suitable than Arnotto (*Bixa orellana*), a plant which grows very rapidly and has the advantage also of being a valuable dye producer, the demand for which in the European market is increasing, or a fence may be made of pepper-pines cultivated upon Kapok trees (*Eriodendron anfractuosum*) these if planted close together forming a very impenetrable hedge.* In using these hedges it is to be remembered that the spores which are carried by the wind upon the leaves are not necessarily destroyed as in the previous case, but the chances of life are against them, as the spores are likely to be washed down by the rain or killed by the light, before they have drifted off again upon the coffee leaves.

It seems remarkable that the danger from allowing the plants to be so distant that the wind can freely penetrate the plantation and bringing with it the spores has been so long overlooked. It was observed that the edges of plantations were more severely attacked than the interior but this was attributed to insufficient shading. Professor MARSHALL WARD, however, knew well the influence of the wind on the disease and mentions plantations free of disease on account of their being protected by strips of forest land, and recommends the separations of plantations by the culture of other plants or of forest ground.

Duration of Protection of Leaves by Tobacco-water.

This depends much on two factors (1st) the frequency of rains, and (2nd) the chance of infection. The latter depends very much upon the distance from diseased plants and on the direction of winds.

That the danger of infection diminishes with the increase of distance from a diseased garden is obvious, but the spores are so very light that the wind can carry them to enormous distances. Thus the hemileia which appeared in Ceylon in 1869 was blown

* Another plan is to make hedges or fences of sticks covered with creepers such as *Antigonon leptopus*, *Ipomeas*, or *Thunbergias*, or again, Teoiute grass (*Euchlena luxurians*) or maize may be planted in rows or raised banks.

over to Sumatra where it first appeared in the Padang uplands. Thence it was carried to Java where it appeared in 1876 in the Botanic Garden at Buitenzorg. After which it spread over the whole of West, Middle and East Java.

In order to find exact data for the effective duration of the tobacco water, plants in pots were placed among some very badly diseased ones in the nursery grounds and were allowed to remain there from March 16th to April 16th in the time of heavy daily rain, and every two days were sprinkled with tobacco water, and in spite of the air being saturated with disease, they were unharmed. A similar batch similarly placed were then treated twice a week only with tobacco water, *i.e.*, every three and four days alternately. These became attacked but not so badly as a similar lot which were not treated at all.

The tobacco water must, in any case, give protection for forty-eight hours. For, suppose the leaves are sprinkled in the morning, during the day while the sun is out the liquid is protecting the leaf and has already killed all the seeds which fell on it before. The rain of the afternoon or evening will wash off the tobacco, so that next day they are quite unprotected again. Directly after the rain falls there is again the chance of infection, principally in the early morning hours, when the young leaves are still wet with rain and dew-drops. The fungus can then begin to germinate, and a few hours after will begin to enter the pore. It can go on growing till the morning of the next day when it is again sprinkled. By this time though the tube has entered a short way into the stoma of the leaf, it is not yet free of the seed, but is still drawing nourishment from it, and it is only when this food is done that it is independent of the seed, and before this it is again sprinkled and the seed killed. Thus absolute security can only be obtained by treatment every two days. Some nursery plants standing a few yards away from badly diseased plants were treated during the first months of the rainy monsoon, viz., November to February, only once a week, and notwithstanding remained free of disease, but perhaps that was because there were fewer wet days than usual then. Later the remedy was applied twice a week, but if it is necessary to do it quite as often as this, is still doubtful. The planter is, however, recommended not to be too sparing where the disease is rampant and increasing every year. This abundant treatment is more adapted for nurseries and young plantations and for protection hedges.

Summary.

Any planter can keep his nurseries free of disease at a little expense by sprinkling them with tobacco water and so start the plants in life in a healthy state. Young plantations can be similarly treated and any spots arising from insufficient wetting of the leaf can be cut out with the scissors or burnt out with sulphuric acid as described above. In fruiting plantations heavy attacks can be prevented by enclosing the gardens by hedges which can be composed either of coffee trees kept free of disease by

tobacco water, or of arnotto or some such shrub, Teosinte grass or of trellises with creepers. If these attempts to arrest and prevent the disease are carried out by all cultivators, it is by no means improbable that the disease will be so reduced that it can never form any obstacle to culture and loss from it will always be a negligible quantity.

Dr. Burck has here shewn that it is by no means impossible to cope with the disease as was stated no great time ago, and that it is a mere question of beginning the struggle early enough. Further experiments may simplify the methods of contending with the disease, but at present this plan is comparatively inexpensive and has proved decidedly successful.

Notes on the Foregoing.

The abstract of Dr. Burck's works I have made is very much condensed from the original. The substance has, however, been reproduced, but I have omitted portions which have no bearing upon cultivation in the Straits Settlements. The whole system of cultivation differs considerably in the two countries. In the first place the seasons are entirely different, here are no distinctly wet or dry seasons but on the whole the seasons are uniform. Again Liberian coffee has alone proved successful here and the damage wrought by the disease is much less with this species than with Arabian coffee. From latest advices, however, we gather that the Arabian coffee in Java seems to be dying down, and slowly but steadily succumbing to the disease. If so, it is much to be feared that Arabian coffee will ere long be absent from our markets, as Java produces the largest quantity next to Brazil, and the unsettled condition of the latter country will probably, for the next few years, produce a distinct falling off in the supply.

Another distinction is in the soil upon which the coffee here has to be grown. Java is a volcanic region and volcanic soil is far more suitable for cultivation of coffee, as well as for several other cultures, than the so called laterite of which the greater part of the Peninsula consists.

At the same time any light thrown upon the habits and requirements of the fungus is of great value, and Dr. Burck's suggestions and observations seem to me to possess, even for the cultivation of Liberian coffee here, a great deal of value and importance. All who have seen a view of the coffee fields in Ceylon, must have noticed the entire absence of any hedges or jungle breaking up the enormous tracts of coffee cultivation. The ground is, it is true, very undulating and hilly, but there is no attempt made to separate the fields at all by hedges. The whole country is open to the sweep of the prevailing wind to carry the fungus spores from end to end of the island, and, indeed, the undulating nature of the ground is in favour of the spread of the the disease. Professor Marshall Ward, when he was investigating the disease in Ceylon, pointed out this very thing, and urged the formation of hedges. It is not probable that this simple me-

thod would have so far arrested the disease as to save the now ruined cultivation in Ceylon, but it would, doubtless, have lessened the violence and rapidity of the attack, and given some chance of combating the disease, by breaking up the whole into more manageable plots. It must be remembered that it is very rare to find any one species of plant growing in masses together unmixed with any other in a natural state. The effect is somewhat like that of herding many animals of one kind together in the same space. However, for crops such as coffee it is essential to do this. They require to be grown under unnatural conditions but as this is unavoidable, it is still possible to break up the plantation at least to a small extent by having belts of jungle, here and there, running through the plantations. The quantity of coffee lost by not putting these belts under cultivation is trifling compared with the advantage to be derived from them. These belts will arrest the spread of fungus spores, and blight. They will also be of signal use in attracting the insectivorous birds which will aid to keep down the insects which injure the coffee, and they will also be useful as supplies of sticks, poles, &c. required from time to time in the plantations. It is of course possible that monkeys and musangs will resort to these jungle patches, and sally forth at night to devour the coffee, but they are tolerably easily kept down in small woods and it is usually when there is extensive forest near the plantation that they are so injurious. Where the jungle has been destroyed, and where there are no bushes to make screens, I would suggest the planting of such trees as, *Adenanthera pavonina*, *Saman*, *Tembusu Erythrinus*. Jacktrees etc., in thick rows, so as to break up the plantations. Nor would I restrict the use of jungle belts to the cultivation of coffee only. With all crops cultivated on a large scale here, I think it would be advisable to break up the plantations, if possible. It may be that with some cultivation no enemy worth considering is yet known, but no plant is entirely free from enemies either fungal or insectal, and although it may seem strange to say that a small jungle belt can and will act as a defence against strong winged insects, yet such is the case, for the insects when they rise in the air high enough to clear the jungle, are very liable to be borne far away over the plantation, and if even they do invade the plantation they come but a few at a time and can be easily dealt with. The peculiarities of insect attacks on crops here must, however, be treated of at some future time.

But with respect to Dr Burck's treatment with the sulphuric acid and scissors, and also the tobacco water treatment. At present the disease in the Straits does not seem to be sufficiently destructive to require such elaborate attacks upon it. For although it is very difficult to find a tree entirely free from attack, yet the Liberian coffee, unless a weak plant, seems capable of resisting any ordinary outbreak. Nevertheless, we may expect, should the cultivation of coffee ever become very extensive, to find, as years go on, the disease becoming in time virulent, and this is the more likely as the soil in which we have to cultivate coffee is immensely poorer than that of Java.

Dr. Burck, it appears, does not attribute much of the virulence of the disease to poverty of soil, yet I have doubts as to whether this may not have played a great part in the ruinous catastrophe of Ceylon. For a long period the same land had been under coffee. There was no rotation of crops, which indeed is impracticable for the most part with any crops except those of annuals or biennials. This constant growth of the same species of plant on the same soil, cannot but remove a large portion of the most valuable salts, and the plants must get gradually weaker, nor does there seem to be any reason to doubt but that weakly plants are more liable to succumb to disease, whether animal or vegetable, than healthy ones. There is abundant evidence of this throughout both the animal and vegetable kingdoms. Of course thoroughly healthy plants may also be attacked, but they have a much better chance to throw off the disease.

I do not think Arabian coffee can ever be successfully cultivated in the Straits Settlements. It seems here to be very liable to produce "brush," that is to say, abnormal flowers, with minute, green, irregular sepals and petals, no stamens, and the pistil very small and apparently effete. I imagine this is due to the permanent dampness of the climate, and absence of any period of rest from growth. It appears to be a preliminary stage of what is known as phyllody of the flower, *i.e.*, conversion of the part of the flower into leaves, instead of reproductive organs. This is common here also in certain orchids as *Phalænopsis Schilleriana*, which produces bulbs and leaves on the flower spike instead of flowers.

On some Enemies to the Coffee in the Straits Settlements.

Besides the fungus, hemileia, the coffee suffers to a smaller extent from several destructive animals, among which are monkeys, musangs, a species of locust, the caterpillar of the bee-hawk-moth and a scale insect.

Of the monkeys the most destructive are the golden monkey *(Macacus sinicus)* and the black monkey (*Semnopithecus sp.*).

The latter does not occur in Singapore but is common in Johor. These monkeys eat the fruit whole, passing the seeds uninjured, and the seeds passed by them are stated to be the best for cultivation. If this is correct it is perhaps due partly to the animals selecting the best fruit, but it is possible also that the seeds are absolutely improved by passing through the animal's body and so being manured, as has been shown to be the case with seeds of hawthorn trees swallowed by turkeys.

The musangs *(Viverra malaccensis)* are even more destructive than monkeys, and a good deal harder to destroy, as they are strictly nocturnal and very skilful at avoiding traps. They may, however, be caught in traps baited with pieces of bananas. On one estate, I am informed, that these animals eat a pikul of coffee per diem.

The locust is a large species of grasshopper not yet identified. It is about 3 inches long, yellowish green spotted with black. The

hind wings are pink and very conspicuous when it flies, which it does very briskly. It does not eat the coffee leaves, but injures the bushes by laying its eggs in the shoots. This it does by making a series of slits in the bark of the shoots spirally, in each of which cuts it deposits a long narrow white egg. The larvæ do not appear to injure the shoot at all, and probably leave the plant as soon as hatched. The shoots, however, soon wither and turn black, and finally fall off, and this is certain evidence of the presence of the locust. As a rule it does not do much harm, but under certain circumstances it may become exceedingly abundant and injurious. It is quite a common insect here, but I have seen it most abundant in Johor. It must be caught in butterfly nets, and destroyed.

The bee-hawk-moth (*Cephonodes hylas*).—The caterpillar of this insect is very destructive to the coffee by devouring the leaves, and clearing bushes with astonishing rapidity. The moth lays its eggs upon the leaves of the trees, and the caterpillars quickly emerge and commence the work of destruction, usually attacking weakly plants. When full grown the larva is about three inches in length and of a bright green colour. The head is small and dull green, the next segment is ornamented with a number of raised yellow dots, the rest of the body is smooth bright green, bluish above, along each side is a raised pink line and down the middle of the back runs a double white line from the head to the tail meeting behind the horn which, like most of the hawk-moth caterpillars, this animal has upon its tail. This horn is curved and sharp, yellow with raised black dots. The last segment and hindmost feet are ornamented with raised yellow dots. The feet are furnished with tufts of hair, but otherwise the caterpillar is quite smooth. When full grown the caterpillar spins a web between the leaves and becomes a chrysalis. It remains in this state for about a fortnight and then emerges as the moth. The perfect insect is very beautiful, it is about 1½ inches long, the body dark green, the tail fan-shaped black and yellow. The wings are perfectly transparent except along the edges, which are of a dull dark red. It is very active and not very easy to catch, flying briskly about in the evening shortly before sundown, and may be seen sucking the honey from the coffee flowers, which it probably fertilizes, but as there are many other harmless insects which do this equally well it may be destroyed whenever met with without detriment to the fertilization of the coffee. It is most easily destroyed in the caterpillar state. The larvæ should be picked off by hands and destroyed. They are most abundant in January, but I have taken it full grown in December, and seen the perfect insect at several different periods of the year.

The scale-insect commonly called black blight (*Lecanium coffeæ*) is also very injurious at times, especially to weakly plants. It may be destroyed by the application of phenyl, diluted with water till it is of the consistence of milk, or by shaking powdered lime over the leaves with a flower dredger. Phenyl water can be applied with aid of a squirt of bamboo, or an ordinary syringe. Many of the scale-insects are protected from most liquids suitable for kill-

ing them without injury to the plants, by the waxy secretion with which they are covered, which prevents the liquid actually touching the insect's body, but phenyl will penetrate the wax and attack the animal. The phenyl should be poured into the water and stirred up till it assumes the appearance of good white milk. A kerosine emulsion is recommended by the Editor of "Notes on Indian Insect Pests," vol. i, p. 7. An emulsion resembling butter can be produced in a few minutes by churning with a force pump two parts of kerosine with one part of sour milk or soap solution in a pail, emulsions made with soap solutions being generally found to be more effective. The liquids should be at about blood heat. This emulsion may be diluted with from nine to fifty parts of water which should be thoroughly mixed with one part of the emulsion. The strength of the dilution must vary according to the nature of the insect to be dealt with as well as the nature of the plant, but finely sprayed in twelve parts of the water to one of the emulsion it will kill most insects without injury to the plants. It should be applied through a spray nozzle.

The white or mealy bug (*Pseudococcus adonidum*) is not as common here, but is also injurious. It should be treated in the same way.

I have received some specimens of coffee branches attacked by a fungus from Johor. This is quite a different kind to the hemileia. It seems to invade the bark of the branches filling them with a white mycelium and eventually forming a flesh-coloured crust on the outside of the twigs, which are then become black and rotten. It appears to be rather consequent on the death of the twigs from some other cause, and though it might perhaps spread a little to healthy parts is not much to be feared. It generally appears where the bushes are very crowded, and where the branches overlap, or where the locality is very damp. The dying and infected branches should be cut off and burned.